

PG&E's NAS Battery Demonstration Projects

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PG&E's Battery Energy Storage Systems



Vaca-Dixon BESS

2 MW / 14 MWh NAS Battery
Vaca-Dixon Substation

Accomplishments

- ✓ *Peak shaving*
- ✓ *CAISO NGR Energy & Ancillary Services*
- ✓ *Renewable Integration*

Current Operation

- Focused on optimizing for and quantifying revenues from participation in energy and ancillary services markets.



Yerba Buena BESS

4 MW / 28 MWh NAS Battery
Customer R&D Facility, San Jose

Accomplishments

- ✓ *Peak shaving*
- ✓ *Power Quality*
- ✓ *Islanding*

Current Operation

- Capacity and power quality
- Islanding backup for the adjacent customer facility.

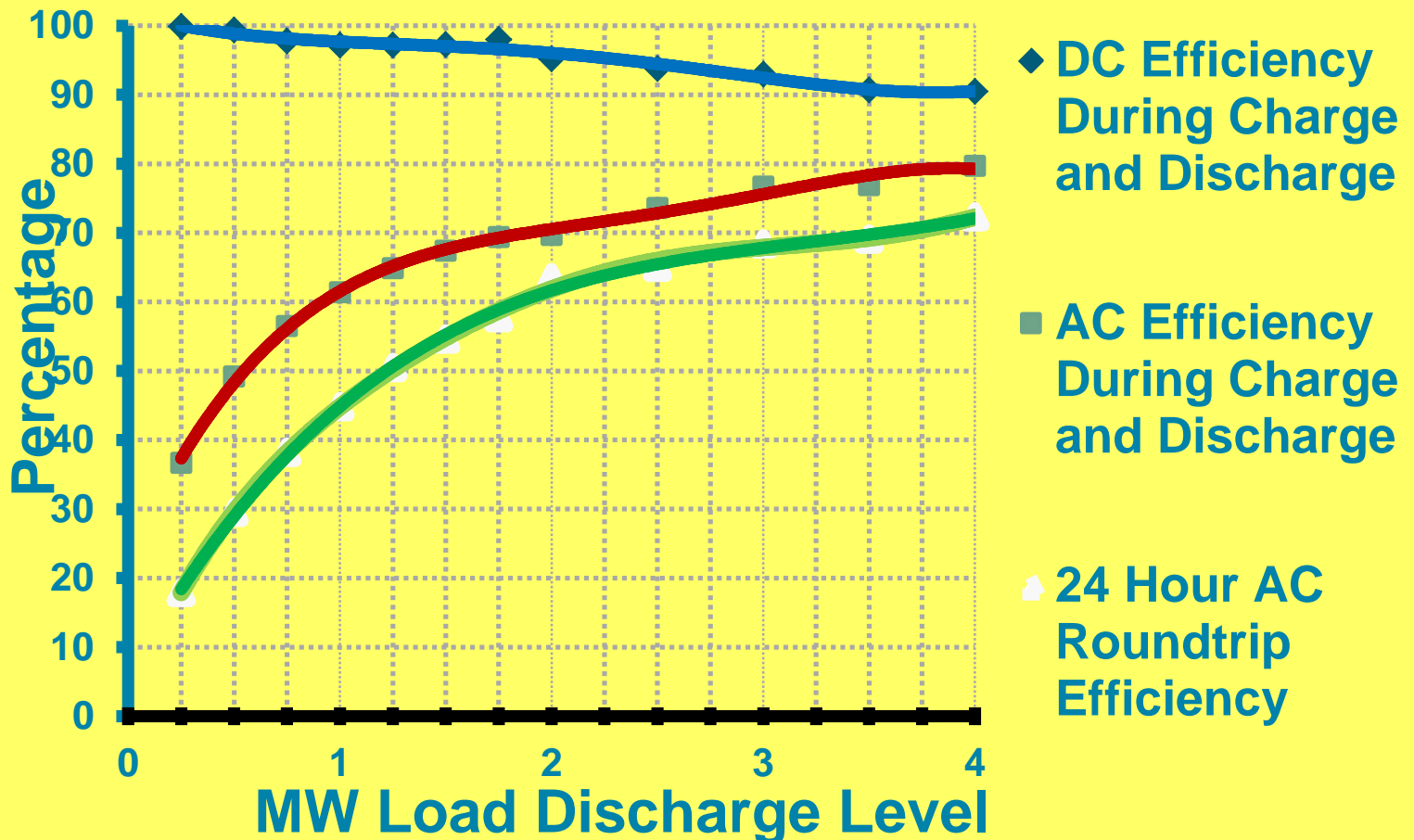


Operational Efficiency Summary

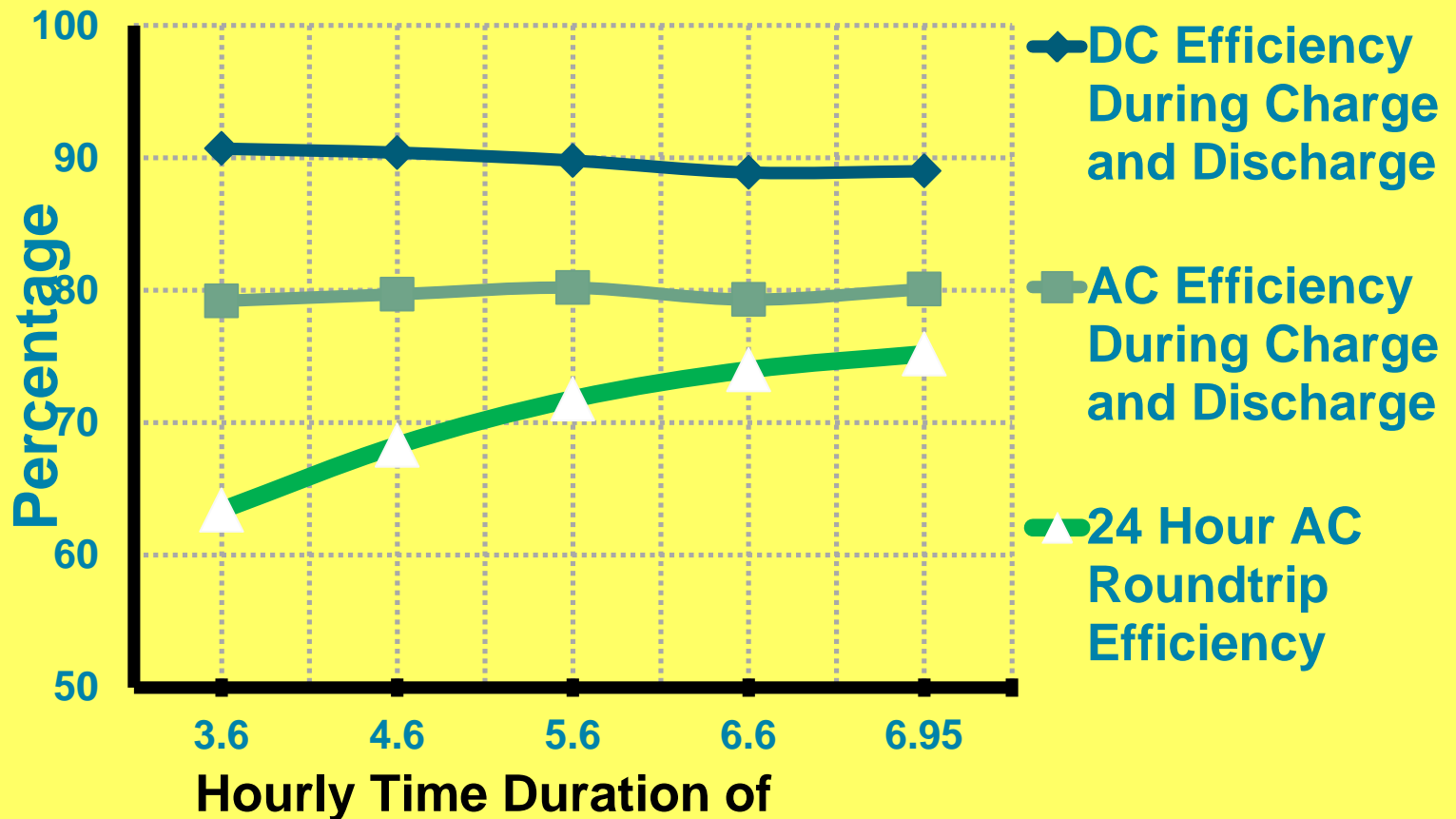
Lessons-Learned

1. The NaS Battery Energy Storage System (BESS) Achieved Very Close To The Manufacturer Performance Levels For Max Power Level , Max Discharge Time, and Max Energy Level
 - a) Utility Side of the Meter: 2 MW, 7 Hours, 14MW-Hours
 - b) Customer Side of the Meter: 4 MW, 7 Hours, 28 MW-Hours
2. The AC Efficiency During Back-to-Back Charge And Discharge Time Periods Remains Relatively Constant At 80% For A Wide Variety Of Discharge Levels. Note: The Overall Effective 24 Hour AC Efficiency Metric Is Highly Dependent On The Length Of The Battery System Idle Time, The Battery Heater Energy Used, The Heater Control System, And The Time Interval Over Which The AC Efficiency Metric Is Calculated.
3. AC Efficiency Improves As Discharge Time Increases. This Is Especially Useful For Relieving T&D system Equipment During Grid Peak Load Time Periods (e.g., From 12 Noon To 6 PM).
4. Power Quality IEEE Standard Levels (Current Harmonics and Voltage Flicker) Were Met (e.g., IEEE 1547).
5. The BESS Operated Successfully For Applications That Encompassed Power Smoothing, Frequency Regulation, Peak Shaving, VAR Control, And Ramping Duty Cycles.

4 MW Plant Efficiency At 6 Hr Discharge Vs. Load



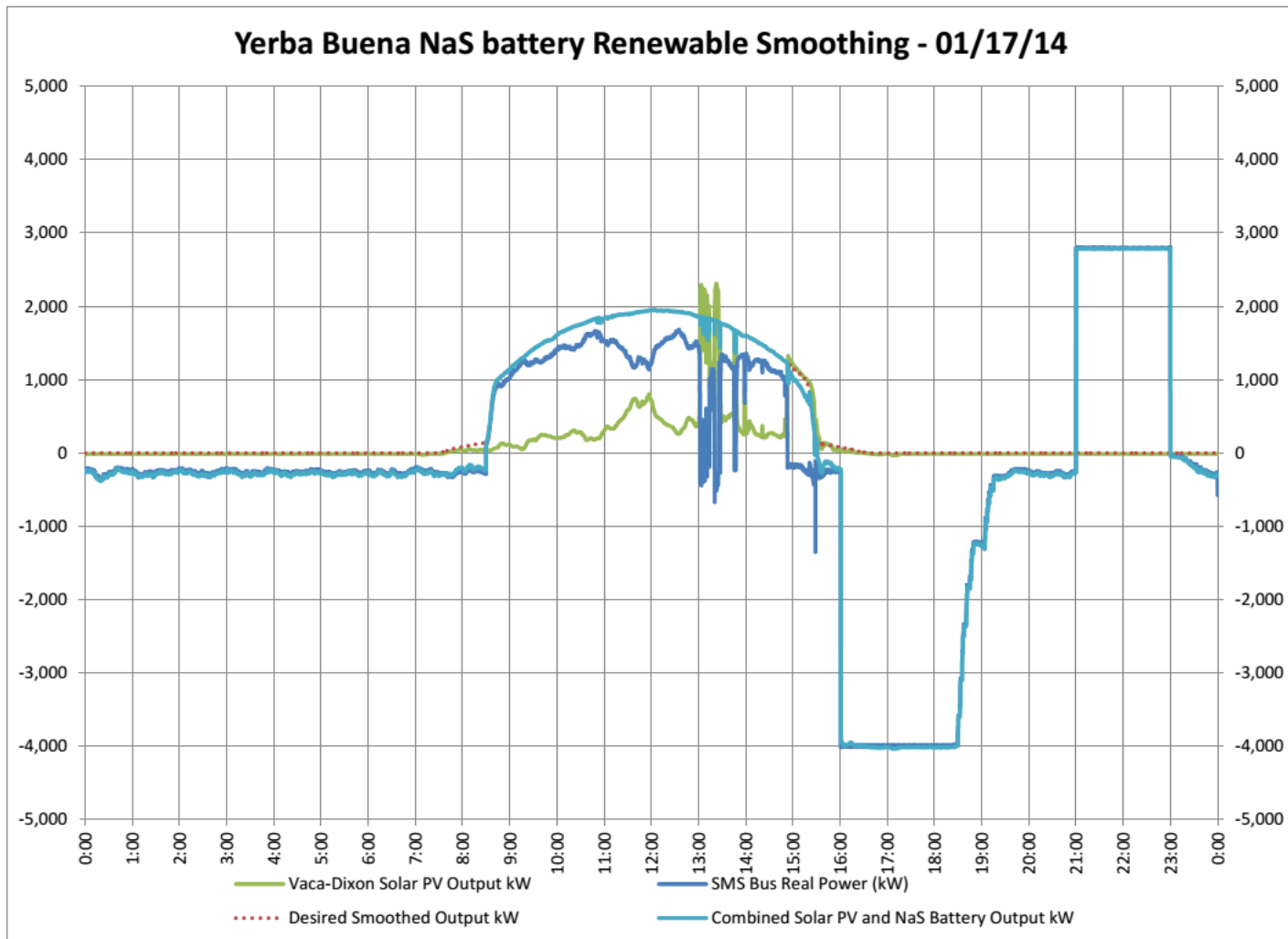
2 MW Plant Efficiency Vs. Discharge Time





Distribution Support: Renewable Smoothing

Demonstrated ability of BESS to smooth output from 2 MW solar array



Note: Historical solar output from 2MW Vaca-Dixon Solar Facility used here, as system does not have connected PV system

Distribution Support: Islanding

Yerba Buena system response to zero voltage condition on feeder. Restored service in less than 4 cycles.

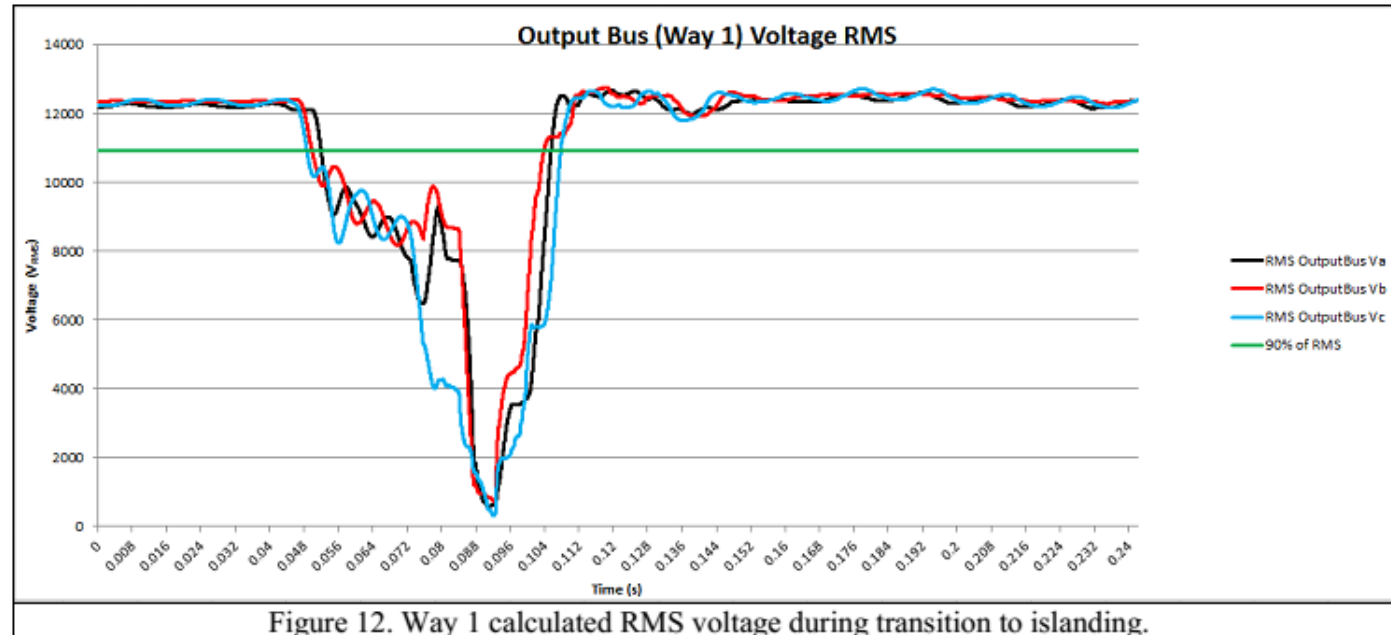


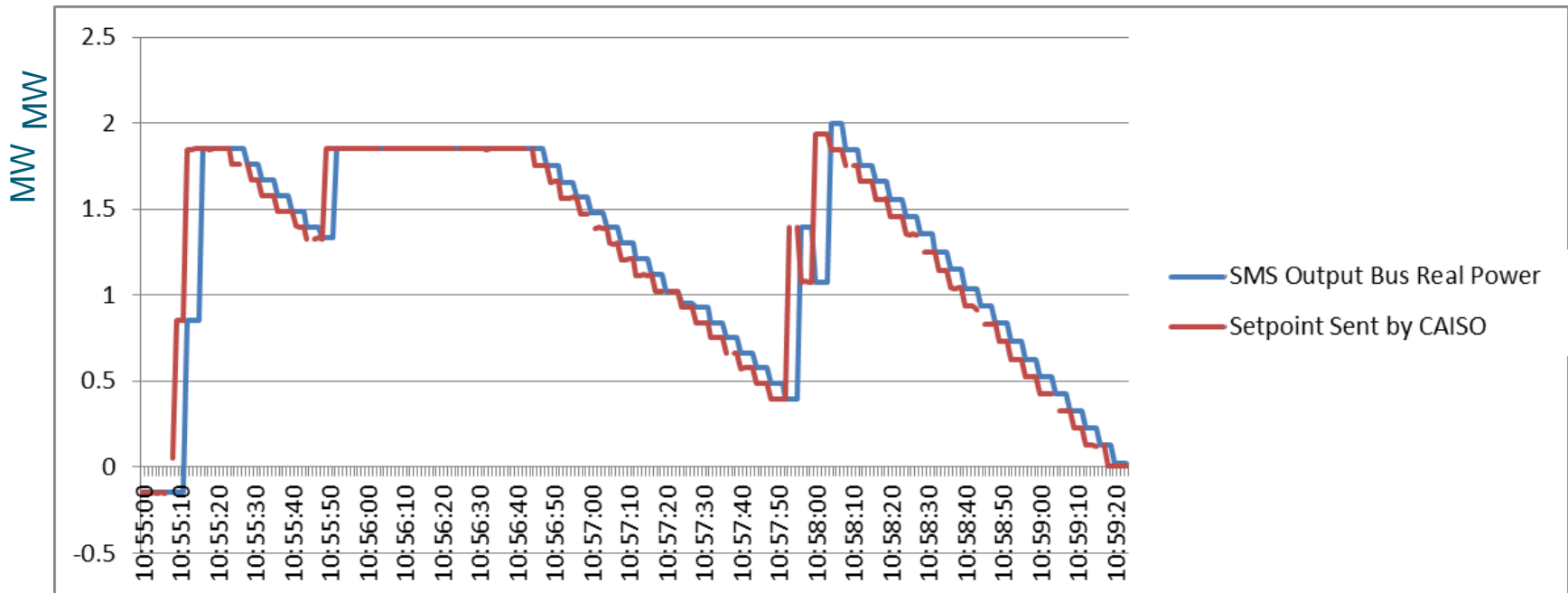
Table 2. Time Each Phase is Below 90% RMS Voltage During Figure 12.

	RMS Voltage (V)	Time (s)	Delta time (s)	Cycles
A Phase	10894.99	0.0520200	0.05352	3.2112
	10925.98	0.1055400		
B Phase	10911.28	0.0498600	0.05396	3.2376
	10914.81	0.1038200		
C Phase	10899.87	0.0487200	0.05906	3.5436
	10918.98	0.1077800		



Market Participation: Ancillary Services (Frequency Regulation) Testing

Response of Vaca BESS to CAISO 4-second AGC signal



Nearly instantaneous response creates potential for extra Pay-For-Performance and Flexible Ramping revenues, although value is unknown at this time.



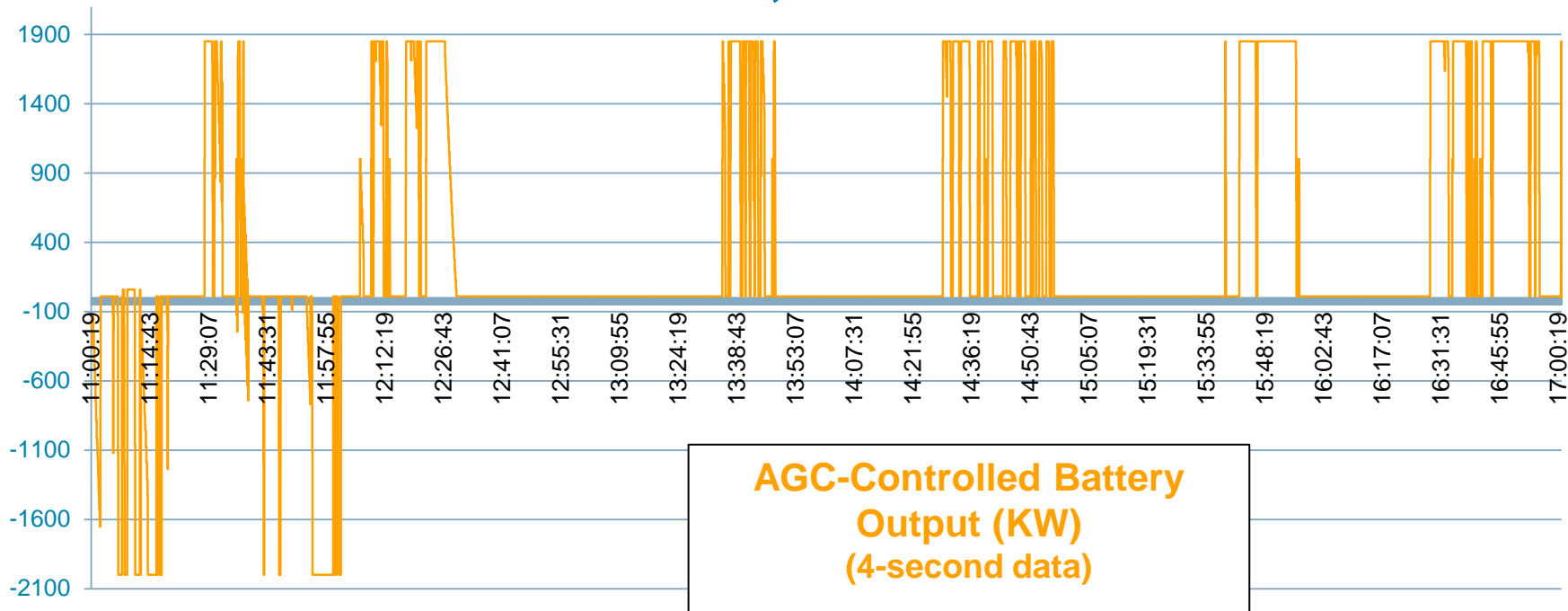
Frequency Regulation

Date: 9/26/14

Award: +1.9 MW Reg Up

-2.1 MW Reg Down

Duration: 6 continuous hours, 11 AM to 5 PM





Summary

- Our experience with the NAS Battery Energy Storage System pilot projects is proving that the technology works and meets manufacturer specifications
- Parasitic and efficiency losses have significant impact on operational costs and constrain use cases
- Have experienced higher than expected failure of power conversion system components
- We are now beginning an earnest exploration of optimizing these resources for CAISO markets, and deploying necessary automation technology to take full advantage of fast-response capabilities of these resources